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CONTROL OF OIL SPILLS

Prepared by

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CONTROL OF OIL SPILLS

by

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Coastal and Ocean Engineering Division
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INTRODUCTION

Greater awareness of ecology and environmental pollution has prompted many researchers to investigate various aspects of pollution control at sea. The most common pollution source at sea is oil. Oil spills may result from an accident at sea, a fire on an oil production platform, a collision of two tankers or a tanker with another ship, accidental rupture of pipes carrying oil, washing of tankers at sea, etc. Other forms of pollution include dumping of chemicals, radioactive waste, and solid wastes.

Concentrating on the control of oil spills, the following subdivisions are appropriate:

1. Prevention of oil from spilling,
2. Containment of oil at sea and in estuaries,
3. Removal of oil from water surface,
4. Chemical treatment of oil in estuaries

PREVENTION OF OIL FROM SPILLING

The best method of controlling oil pollution is, of course, prevention of pollution in the first place. This may include such techniques as removing oil from stricken tankers, continuous monitoring of oil wells to prevent blowouts and leakage, killing wild wells at sea to prevent oil spills, and containing oil leaks under the water surface.

* Presented at the First West Gulf Regional Convention of the Propeller Club of the United States at Galveston, Texas on April 1, 1971.

The U.S. Coast Guard research and development program for oil pollution control systems included (in 1970) collapsible, inflatable rubber-coated bladders, each capable of transporting 140,000 gallons of oil from a distressed tanker. In a collapsed state, the bladders are approximately the size of a small automobile and can be transported by air to the scene of a potential oil spill. When inflated and filled with oil, these bladders extend to a length of some 140 feet and resemble large floating air mattresses or water beds. The balance of the system components includes a submersible hydraulic pump, a prime mover, flexible transfer piping, fittings and assembly tools. The procedure in filling the bladders involves air-drop of the equipment in the proximity of a stricken tanker, delivery of a pump and prime mover by a helicopter onto the tanker, assembly of the necessary components, and filling the large rubber containers with oil. Finally the oil-filled container may be towed to safe anchorage for later disposal by pumping out oil and salvaging it.

Another preventive method involves around-the-clock surveillance of oil wells using monitoring systems to compare all the recording variables with permissible operating limits for a given well. Any major variations are reported by alarm lights and signal horns on an occupied well or by remote control for automatically-operated wells. Tenneco Company developed an effective method of closing-in offshore oil wells which are out of control. Since most wells in the Gulf of Mexico are relatively low pressure, shaped charges may be used to cut out windows through the pipe. Using one of the windows, the divers can apply a crimping device in the tubing that will restrict the flow of oil in the pipe. The next step is to introduce sealer balls into the flow stream through the hose. The flow lifts the balls until they are trapped by the crimp in the tubing. Later, the balls are followed by a finer material to form an impermeable plug in the pipe. This method is

limited to areas where relatively low pressures are encountered. (1)*

Oil seeps from the cracks in the bottom of the ocean or from the pipes laid at the bottom may be collected using an umbrella-type device. One method suggested is a polyvinyl chloride over a nylon fabric tent anchored to the bottom and held in position by a flotation buoy over the center of the tent. Another idea consists of an underwater storage or trap tank made from fiberglass or other materials and having a flexible top.

CONTAINMENT OF OIL AT SEA OR IN THE ESTUARIES

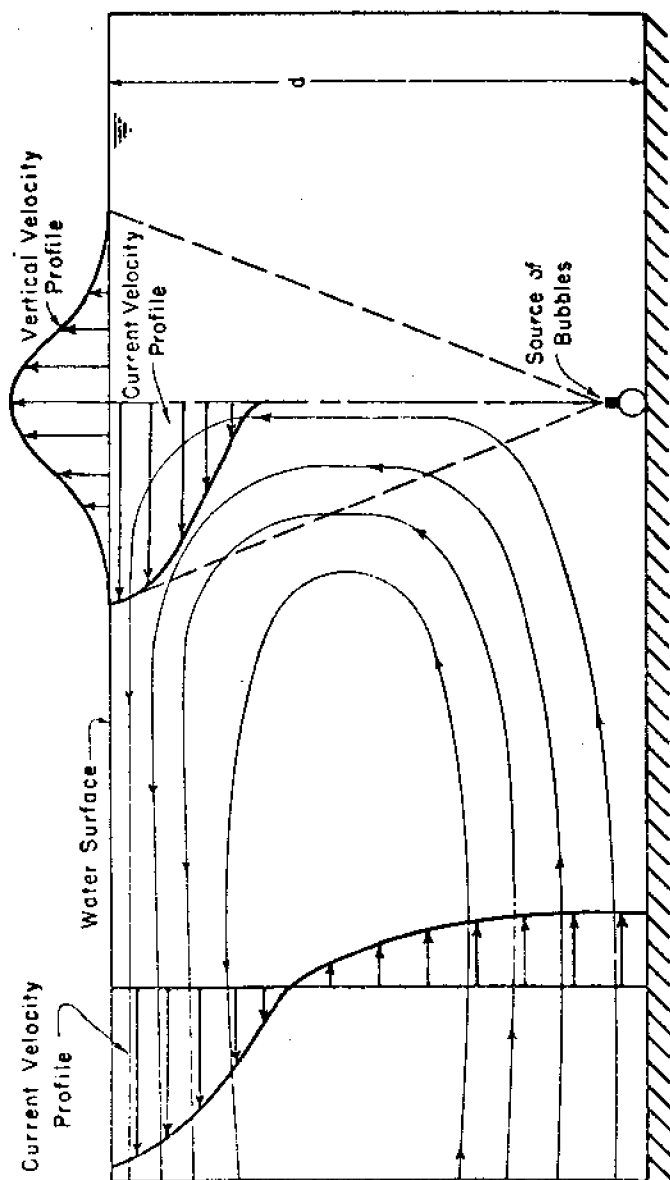
Oil may be contained at sea by several methods. Two methods which look promising are

- (1) a pneumatic barrier, and
- (2) a mechanical barrier.

A large experimental program in the laboratory on the pneumatic barrier has recently been completed at Texas A&M University. This project, conducted under a sub-contract from Wilson Industries, Incorporated to Texas A&M University's Coastal and Ocean Engineering Division, involved a pneumatic-type barrier which may be used for containment of oil at sea or in estuaries. The study was sponsored by the U.S. Coast Guard. (2)

Air bubbles released from below the surface of liquids such as water will rise to the surface because the buoyant force is greater than the combination of fluid drag on the bubble and its weight. Bubbles rising to the surface drag water particles along with them, creating an upward flow. After reaching the surface, the air bubbles are released to the atmosphere. The upward liquid momentum, however, is deflected into two parts and causes surface currents in opposing directions (Fig. 1). Provided a number of small bubbles continuously flow from a submerged duct or pipe, a steady surface

* Numbers in parentheses refer to bibliography listed on page 37.



(from Reference 2)

Figure 1
Qualitative Pattern of Surface Currents Produced
By Air Bubbles. Pneumatic Barrier.

current can be used to oppose the spreading oil of a given depth. Currents produced by the pneumatic barrier essentially contain the oil on the surface when equilibrium is established. The pneumatic barrier has been used successfully in the past to reduce wave height, during harbor construction to reduce wave forces on piers and on other temporary installations. In this case, the barrier is called a pneumatic breakwater.

Pneumatic barriers have also been used to prevent river water from freezing at ferry crossings and at water intakes upstream of dams, to prevent salt water intrusion at ship locks, and to keep debris and oil from flowing into the locks.

PNEUMATIC SYSTEM REQUIREMENTS AT SEA

Environmental Conditions

The environmental conditions imposed by the U.S. Coast Guard were quite stringent, the upper limits for effective performance being:

- (a) 40 miles per hour wind at standard height, gusts of up to 60 miles per hour lasting no longer than 5 seconds each hour,
- (b) Significant wave height-10 feet
Height of highest 1/10 of waves-13 feet
Significant wave period-7.5 seconds
- (c) Sea current-2 knots

The upper limit for physical integrity was

- (a) 60 miles per hour average wind at standard height gusts up to 90 miles per hour lasting no longer than 5 seconds each hour
- (b) Significant wave height-20 feet
Height of highest 1/10 of waves-28 feet
Range of periods - 5-17 seconds
- (c) Sea current-3 knots

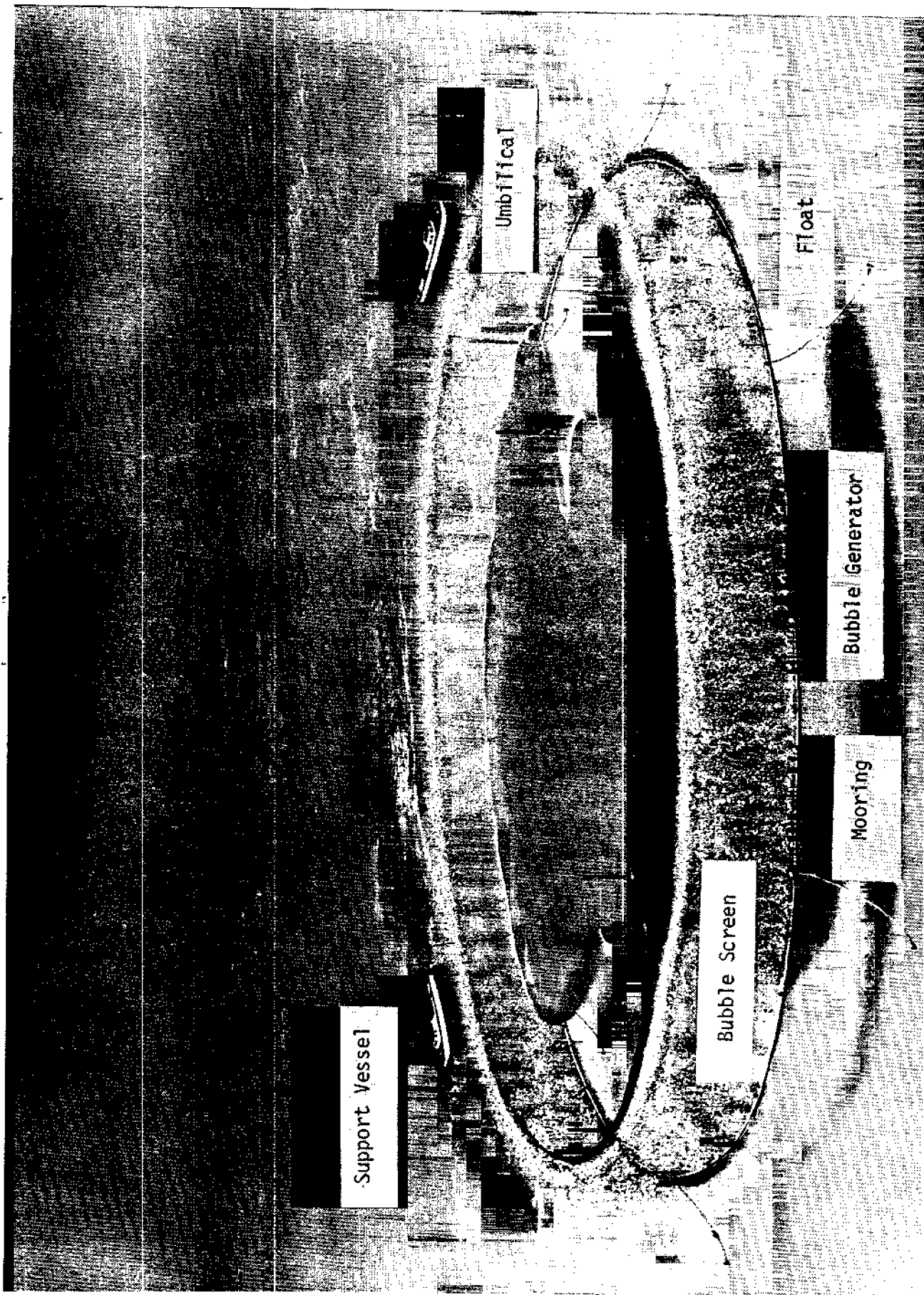
General Requirements

The pneumatic barrier consists of a manifold pipe made of steel and submerged at the required depth, air supply umbilical pipes, and compressors for providing the required amount of air at the desired pressure. (See sketches 1 and 2).

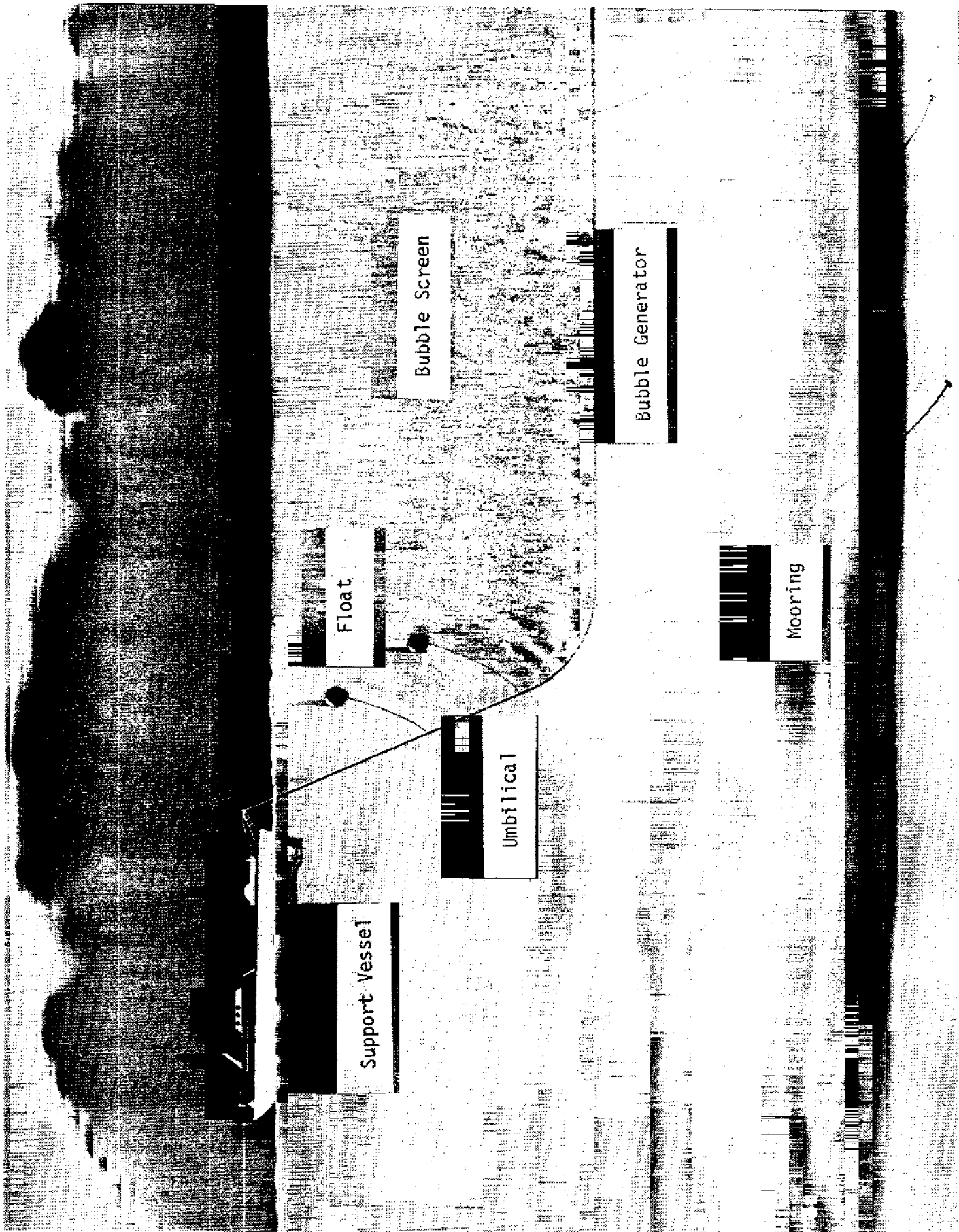
The main manifold pipe releasing air to produce a pneumatic barrier is located about 25 feet below the water's surface. The hole spacing along the main pipe, determined in the hydrodynamics tests, is recommended to be six to 12 holes per foot of pipe. The hole size required is between $1/32$ and $1/16$ inches. Air flow was determined to be in the range of one cubic foot per second per foot length of pipe. This rate of air flow produces a surface current of five feet per second. The power required at the manifold ranges between 5 and 12 horsepower per foot length of pipe, depending on the overpressure in the pipe. Frictional losses in the supply pipes are considered negligible so that approximately the same power will be required at the compressor.

Initially, a flexible Poly-Vinyl-Chloride (PVC) pipe was considered for the manifold pneumatic barrier. After serious consideration, it was decided that the pipe should be rigid to facilitate control of placement and flotation and to provide the necessary tensile load-carrying capability. A suitable pipe is, therefore, steel.

The size of pipe depends on the type of compressor used and will be between 4.5 and 7.0 inches in diameter. A rotary, positive displacement, axial flow compressor driven by a gas turbine engine supplies 18,675 cubic feet per minute at 49.7 pounds per square inch absolute and requires 2,255 Brake Horsepower. This unit can supply air for 310 feet of pneumatic barrier at 7.27 Horsepower per foot length of barrier. The weight of the unit may be excessive, requiring further development to reduce it. Another type of



Sketch 1 - Pneumatic Barrier Deployed At Sea. (from Reference 2)



Sketch 2 - Pneumatic Barrier Deployed at Sea. (from Reference 2)

unit is the gas turbine-driven air compressor which will deliver 20,000 cubic feet per minute at 40.0 pounds per square inch gage. This unit supplies air for 210 feet of pneumatic barrier and can be loaded on a C-130 aircraft. Since this unit provides compressed air at pressures higher than required, the pneumatic barrier pipe can be reduced to 4 inches in diameter.

The connectors are of the hub and clamp type and are readily obtainable. The umbilical pipe can be made of nylon reinforced neoprene-covered flexible sleeves, also readily available.

The pneumatic barrier pipe has a primary and secondary flotation system. The primary system consists of fluidic logic devices and air bags, while the secondary flotation system is composed of large polyethylene floats attached to the pipe with 30-foot long nylon ropes.

Transportability

Since the system must be transportable by air, it has been divided into four subsystem packages:

Package I Machinery - Turbine-driven compressor, a machinery hull, a cradle, and a pallet. Estimated weight of the package is 21,000 pounds.

Package II - Inflatable rubber fuel tanks.

Package III - Bubble Screen - This package will contain a complete set of 200 feet of pipe sections, clamps, one umbilical, and floats. Approximate weight is 3,000 pounds.

Package IV - Mooring - This package will contain four anchor and mooring lines to connect the bubble generators, and machinery hulls as shown in Fig. 2. Approximate weight is 12,000 pounds.

All packages are secured to standard C-130 aircraft pallets. The packages are removed from storage and transported to the C-130 aircraft by a 25K aircraft cargo loading truck. The packages are ground winched onto the C-130. Three aircraft are required for each 200 foot module of

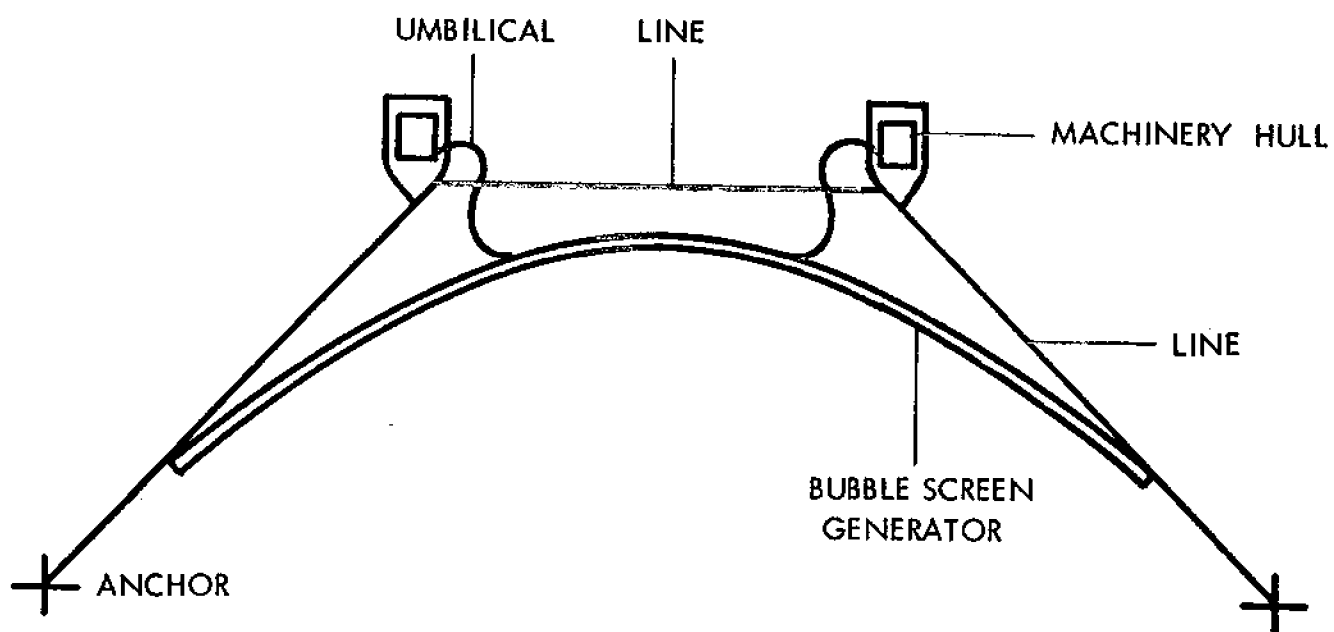


Fig. 2 - Anchor System (from Reference 2)

bubble barrier. At the airfield nearest a port close to the oil spill, the packages are offloaded onto flatbed trucks for transportation to docks or Coast Guard station, Packages III and IV are loaded onto a buoy tender. Packages I and II are set in the water. Jet fuel tank trucks will load 120,000 gallons of fuel into the fuel bags, an eight day fuel capacity. Estimated time for transport and loading is two to four days, depending on the availability of buoy tenders.

Because of the towing characteristics of the fuel tank, the tenders require six to 24 hours to reach the spill site.

Adaptability of the System

The oil containment system should be designed for a number of possible combinations of waves, currents and winds. Two such combinations are selected as an example as shown in Fig. 3.

(a) Case 1

Wave, current and wind coming from one quarter. In this case the pneumatic barrier need not be placed around the oil to be contained. The pneumatic barrier could be deployed by two U.S. Coast Guard ships in the manner shown in Fig. 3.

(b) Case 2

In this case the waves and wind are coming from one quarter and the current from the opposite direction to the waves' direction.

The pneumatic barrier must enclose the oil spill in such a case.

The system is compatible with existing equipment and designed so that it can be deployed, wholly or in part, by any of the existing ships or aircraft of the U.S. Coast Guard.

Emphasis on Unique and Significant Features of Design

The pneumatic system is easily deployed and retrieved. (See Sketch 1 and 2). The system can be operated by compressors on board existing ships

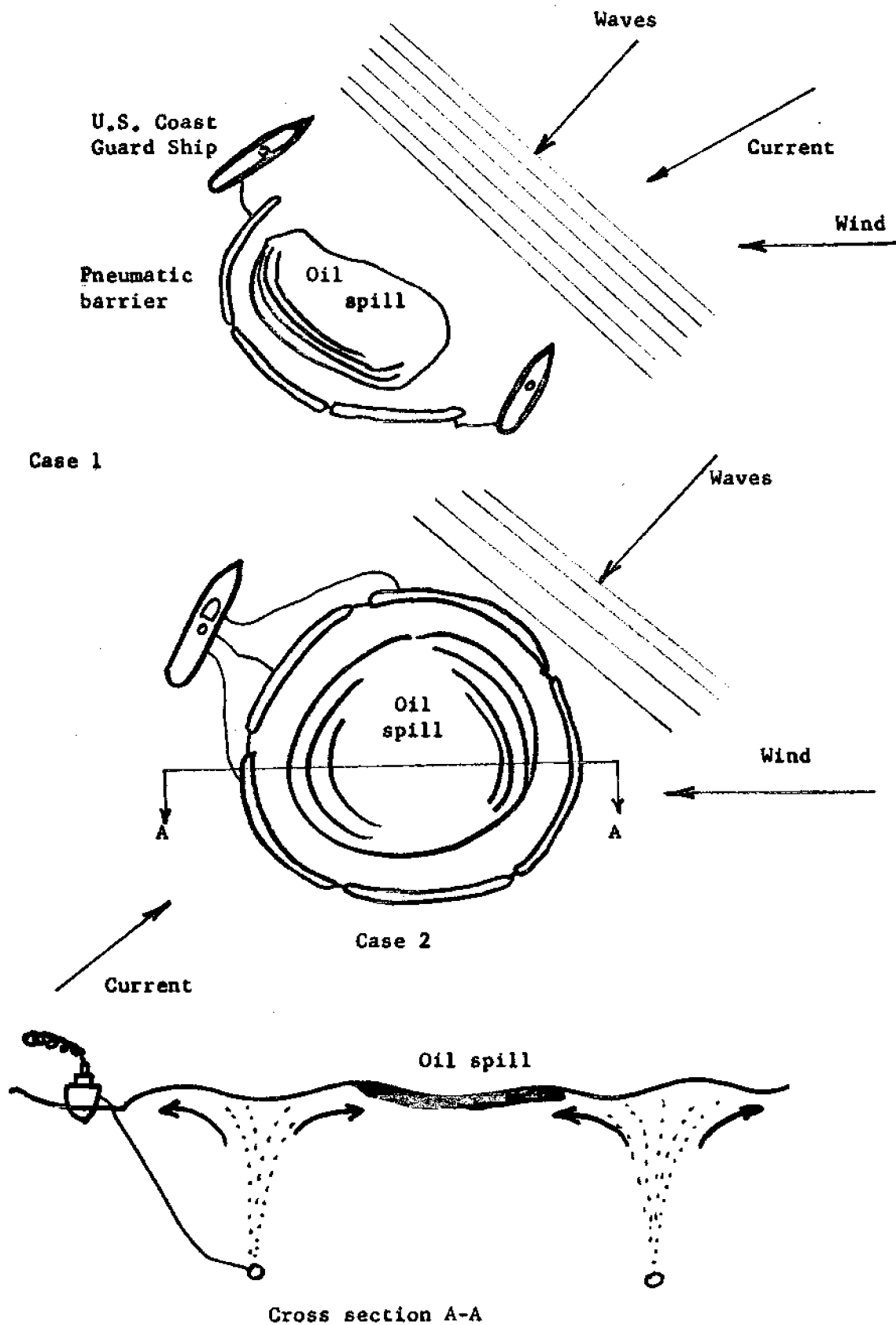


Fig. 3 - Pneumatic Barrier Containment System

(from Reference 2)

or from floating platforms or barges placed at the spill site. The pneumatic system will allow ships or other craft to pass over the barrier without causing removal or shut down. (Sketch 3)

Another advantage is that wave attenuation will be achieved on the order of 5-10 percent. If environmental conditions are less than those specified, a much greater wave attenuation may be expected, permitting an easier and more efficient disposal of the oil from the contained area.

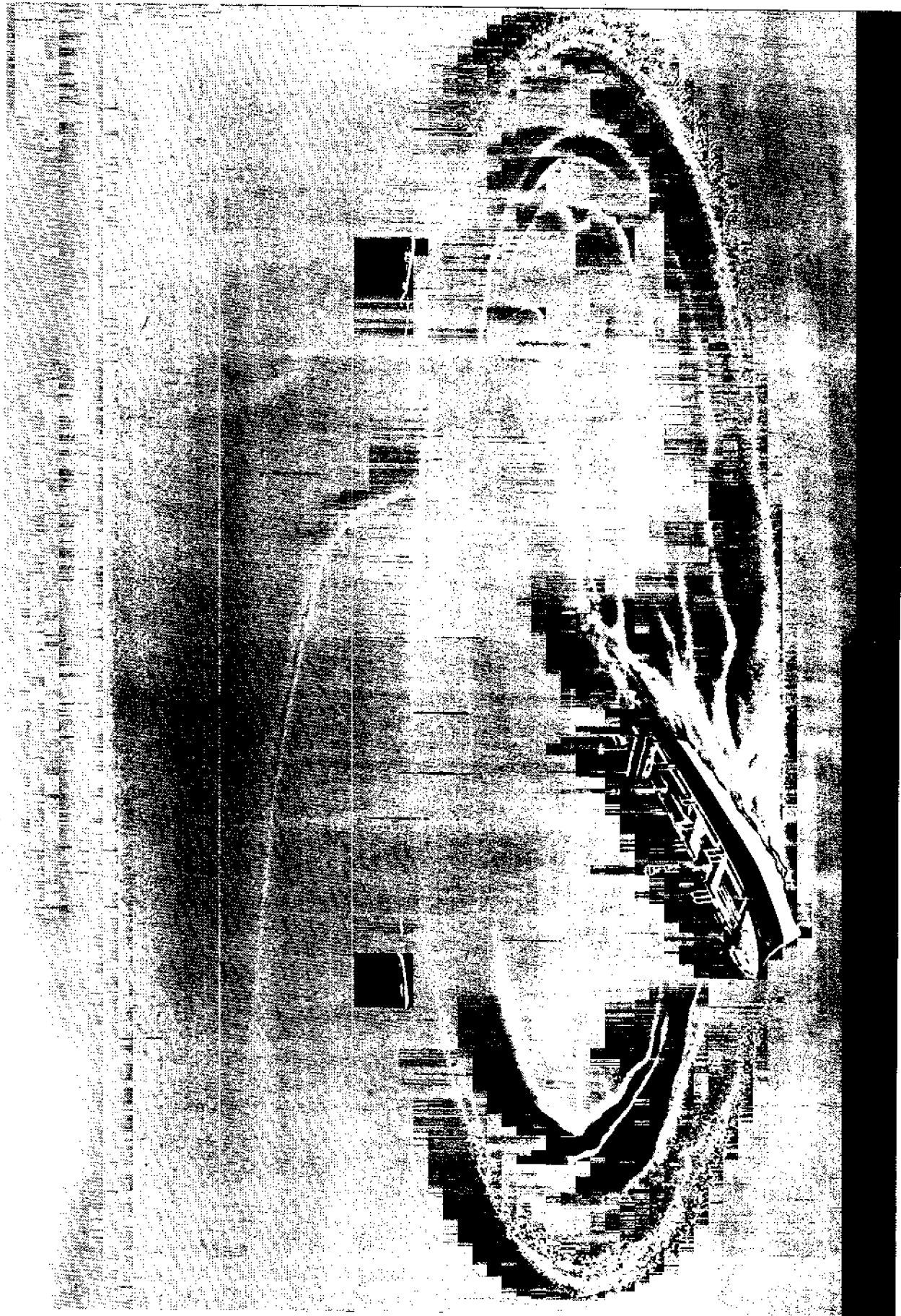
Summary

A pneumatic barrier concept has proven to be a most effective oil containment device under environmental conditions specified. Its effectiveness was demonstrated in the laboratory at various water depths up to 7.5 feet. The air, power, etc. requirements have been based on experimental studies. Since the air discharge and power requirements tend to decrease with an increase in model size, it can be expected that the air and power requirement may be further reduced for the prototype installation.

The most demanding environmental requirement is the 2 knot current, Fig. 4.

For any pneumatic generated velocity (U_{max}) the resulting mean oil depth contained can be determined for the range of specific gravity oils of interest. A 2 knot prototype current (3.38 feet per second) is used in the plot. No wind set-up effects are included, but mean oil containment depths can be estimated with wind by using only 2/3 of the values indicated. These results are tabulated below.

Barrier Design Velocity U_{max} (ft/sec)	SG of Oil	Mean Oil Depth Contained (Feet)	
		No Wind	Including Design Wind
5.0	0.75	0.225	0.15
5.0	0.85	0.370	0.295
5.0	0.95	1.140	0.76



Sketch 3 - A Ship Passes Freely Over a Pneumatic Barrier.

(from Reference 2)

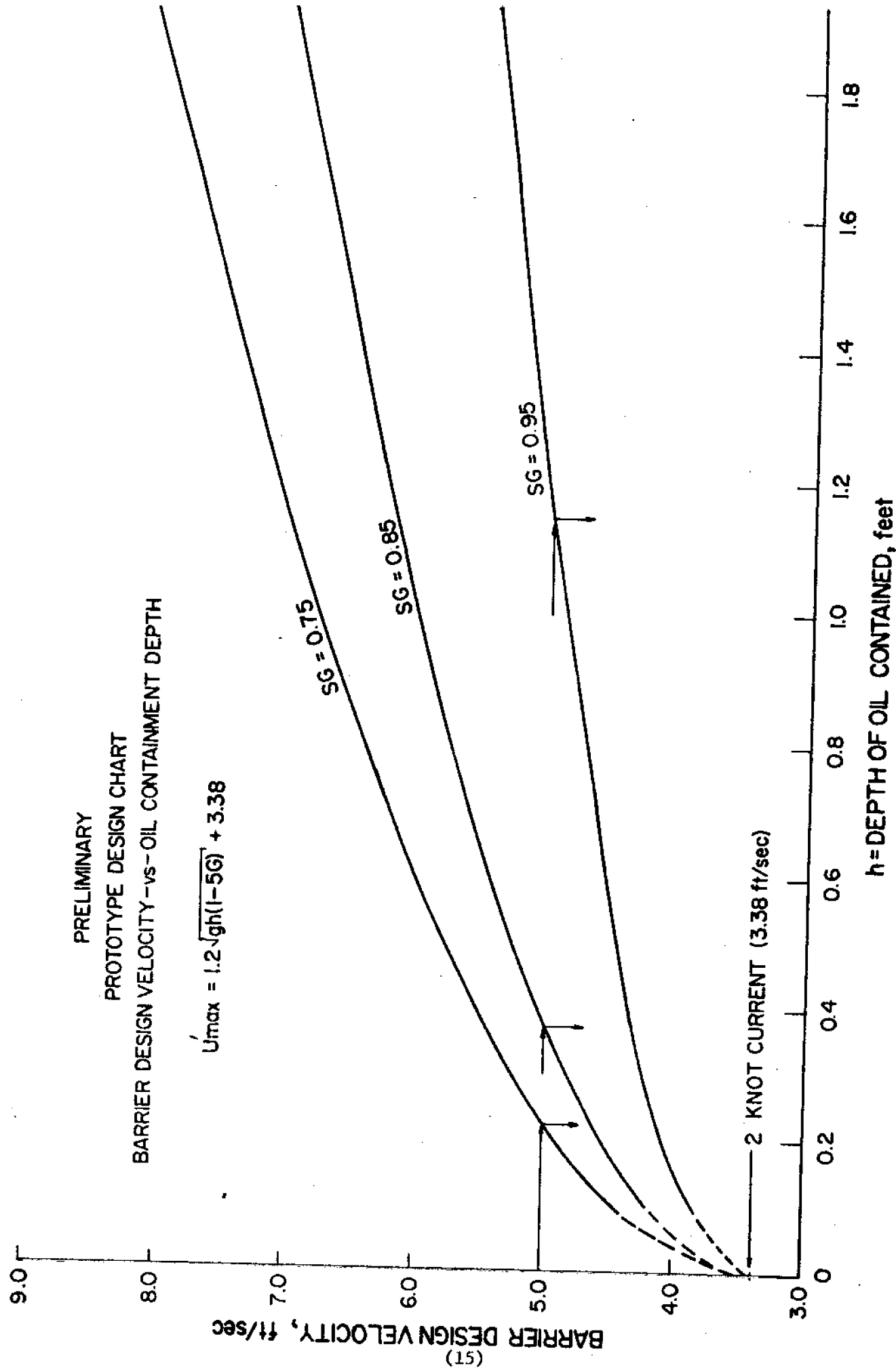


Figure 4 - Recommended Prototype Design Chart
 U_{max} versus h

(from Reference 2)

PNEUMATIC SYSTEM REQUIREMENT IN ESTUARIES

The surface water current or power requirements for environmental conditions normally encountered in estuaries or in semi-sheltered bays are considerably lower than those encountered at sea.

Surface Current Required

The maximum surface current generated is proportional to the unit air flow raised to one-third power. The constant of proportionality is strongly dependent on depth of manifold pipe and is practically independent of manifold hole size. The following formula is recommended for design purposes:

$$U_{\max} = 1.5(gq)^{1/2}$$

where U_{\max} occurs at a distance of about 0.3-0.6 pipe depths from the centerline of the barrier,

g is acceleration due to gravity, 2 feet per second square

q is air flow rate per unit length of barrier, cubic feet per second per foot.

The principle of linear superposition applied to combine the current produced by the pneumatic system and the existing surface current was found to hold.

If the surface current is reduced to 1 knot, the air discharge and horsepower may be reduced from 1 cubic feet per second per foot to 0.5 cubic feet per second per foot and from approximately 8.0 to 4.0 Horsepower per foot, assuming one atmosphere overpressure in the manifold located 30 feet below the surface. Figure 5 presents the combined results for a 1 knot prototype current (1.69 feet per second). The results are as follows:

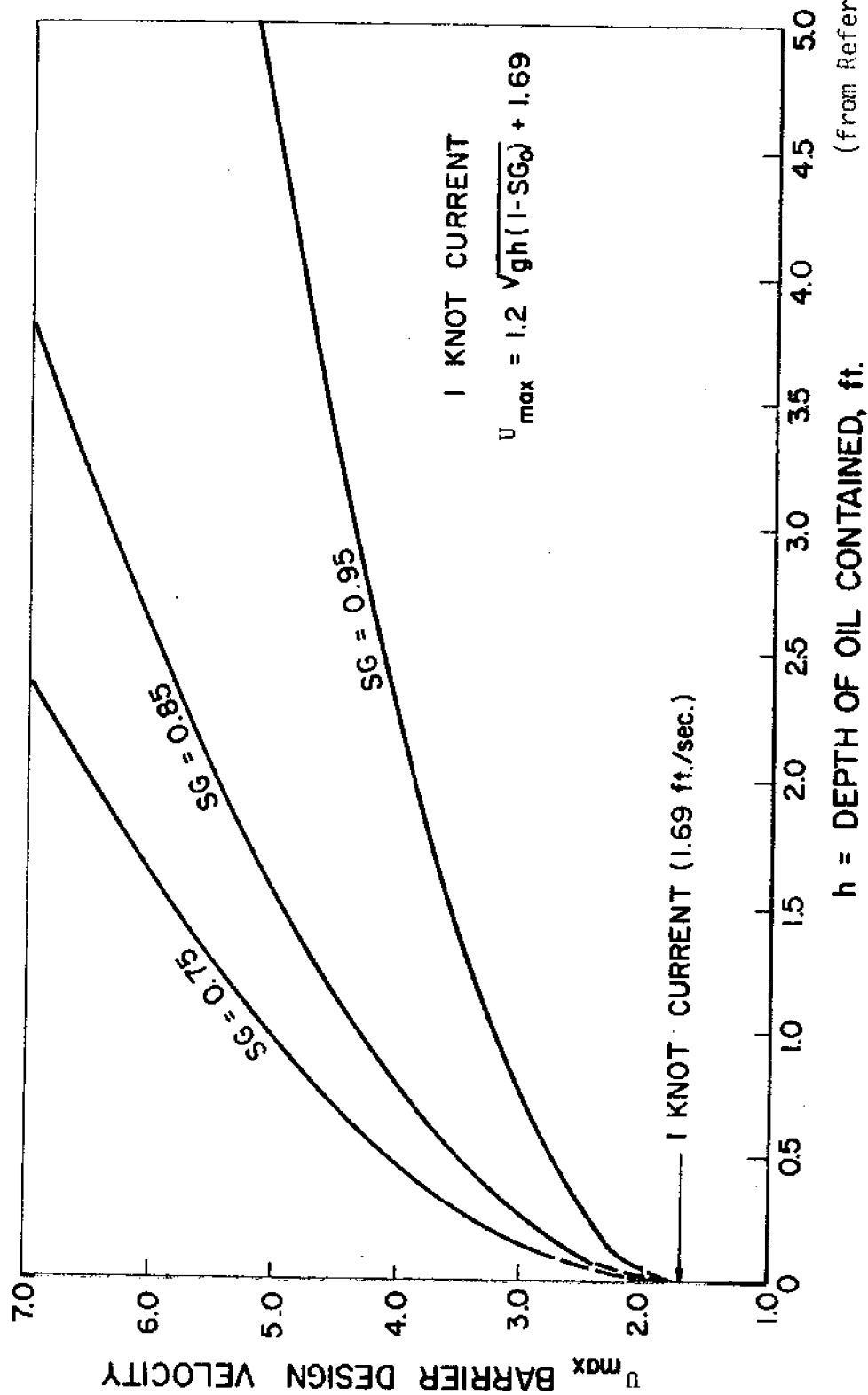


Fig. 5 - Prototype design chart, 1 knot current

Barrier Design	SG of Oil	No. W.	
Velocity U_{max} (feet/second)			
5.0	0.75	0.95	
5.0	0.85	1.55	
5.0	0.95	4.60	3.05

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The surface current and power requirements may be further reduced if the estuarine current is less than 1 knot.

Densimetric Froude Number

One of the dimensionless parameters describing the performance of the pneumatic barrier is the Densimetric Froude Number (N_F) which may be shown to be⁽³⁾:

$$N_F = \frac{\text{forces due to gravity}}{\text{forces due to inertia}} = \frac{U_{max}}{gh(1-SG_o)} \quad (2)$$

where U_{max} = maximum surface velocity

g = acceleration due to gravity

h = thickness of oil when failure of the barrier occurs

S.G. = specific gravity of oil

Denoting the critical value of N_F where failure occurs as $(N_F)_{crit}$, equation (2) may be written as

$$(N_F)_{crit} = \frac{U_{max}}{gh(1-SG_o)} = \alpha \quad \dots \dots \dots (3)$$

where α = Dimensionless critical coefficient.

The values of α may be determined experimentally.

Sjoberg and Verner⁴ obtained experimental values of α between 1.0 and 1.4 with an average value of about 1.2. Experimental work at Texas A&M University confirmed this value of α . When currents were introduced in the laboratory

flumes it appeared that the superposition principle holds true (see Figure 6) and that α is also equal to 1.2.

Experimental tests in a wave channel with long swell wave form indicated that critical value of Froude Number was still between 1.0 and 1.2 (Fig. 7). However for breaking waves at a barrier, other experimenters found the value of $\alpha = 2.7$.

Power requirements for the pneumatic barrier may be expressed as

$$\text{HP/ft} = \frac{q\gamma H}{550} \dots \dots \dots (4)$$

where q = air flow rate in cfs/ft

γ = specific weight of liquid

H = pressure head required to release the air

Basco³ presented an example with a manifold located at 25 feet depth, manifold pressure head equal to 17 feet of water (Fig. 8).

Although the power requirements to contain oil under severe environmental wave conditions are high, the pneumatic system should be considered for applications near the coast, in estuaries and around oil platforms. The pneumatic system is an effective oil containment device.

MECHANICAL BARRIERS

Many mechanical barriers have been proposed during the last two years. One of the more promising barriers which can operate under both the wave and current conditions was evaluated at Texas A&M University^{5,6}. Developed with consideration of barrier dynamics in mind, the device has been designed to separate the oil retention skirt from the rigid, highly-loaded tension cable (as shown in Fig 9). This was accomplished by:

1. Building the oil retention skirt in a scalloped configuration with scallops two feet wide to reduce the tension in the barrier to a very low amount, allowing it to move vertically in response to wave action. For a one knot current, barrier skirt

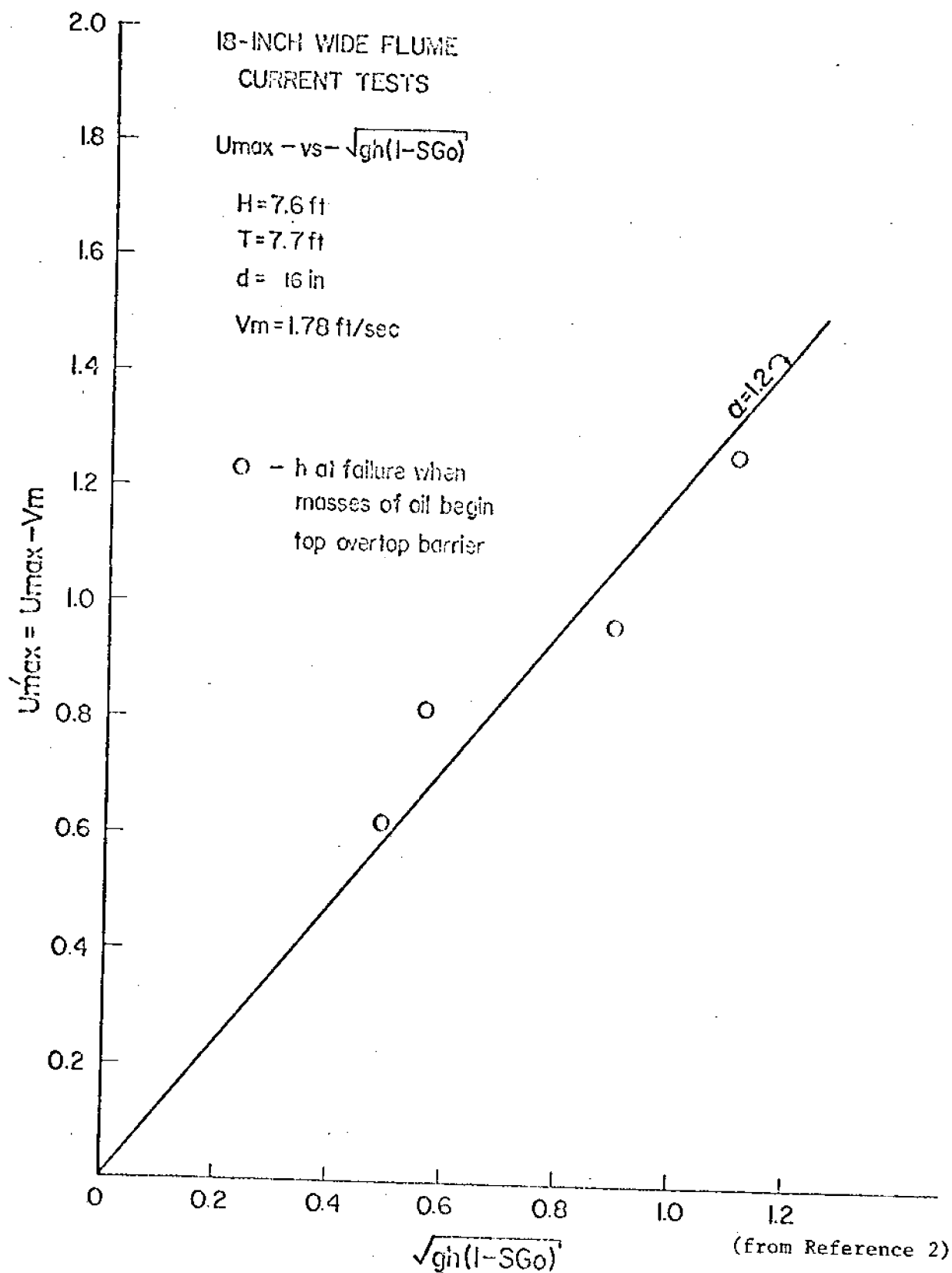


Fig. 6 - Maximum relative velocity as a function of $\sqrt{gh(1-SG_o)}$

MODEL WAVES
1:25 SCALE RATIO
 $U_{max} - \text{vs} - \sqrt{gh(1-SG_0)}$

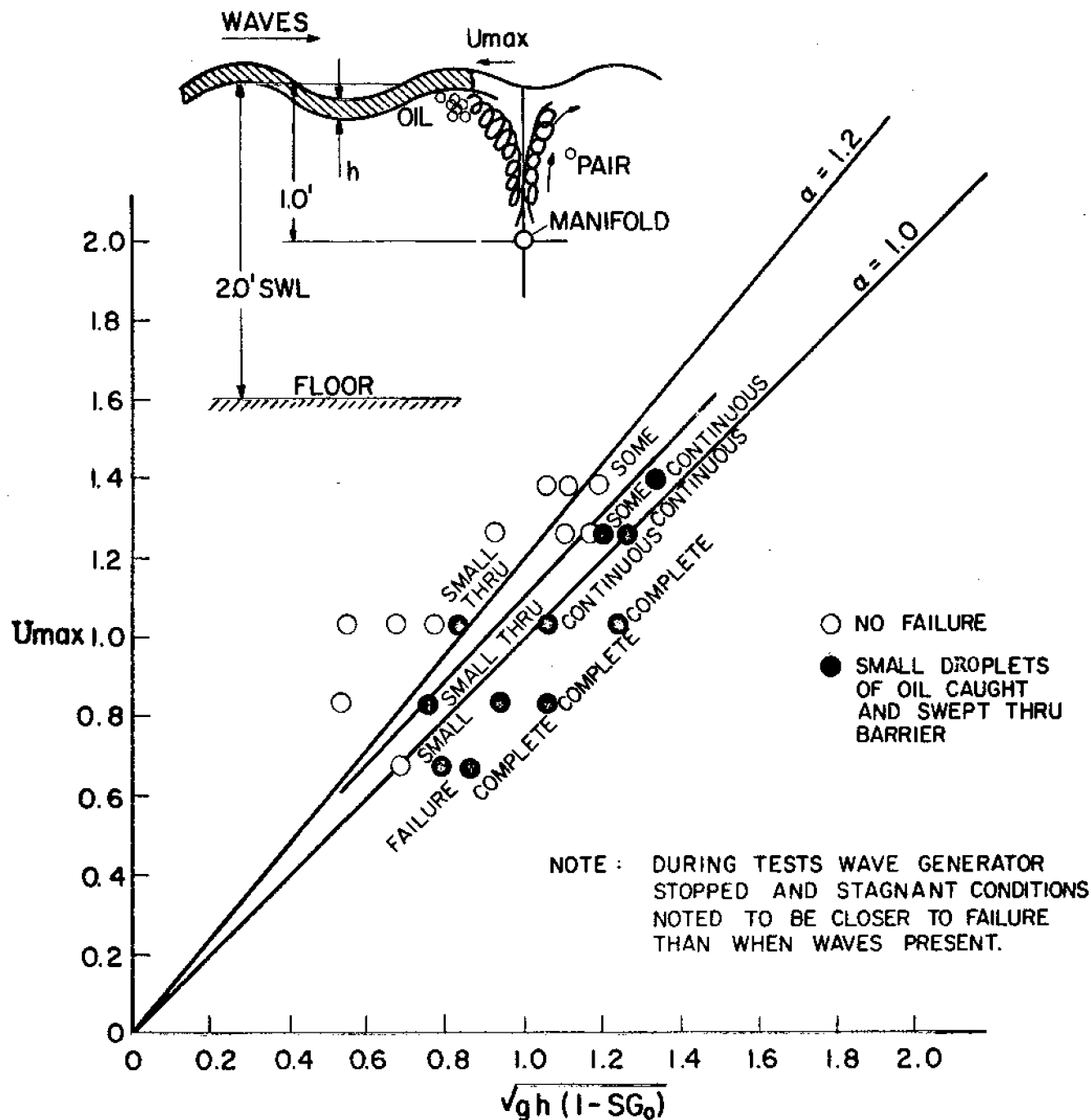


Figure 7 - U_{max} versus $\sqrt{gh(1-SG_0)}$ Under Modeled Design Waves (from Reference 2)

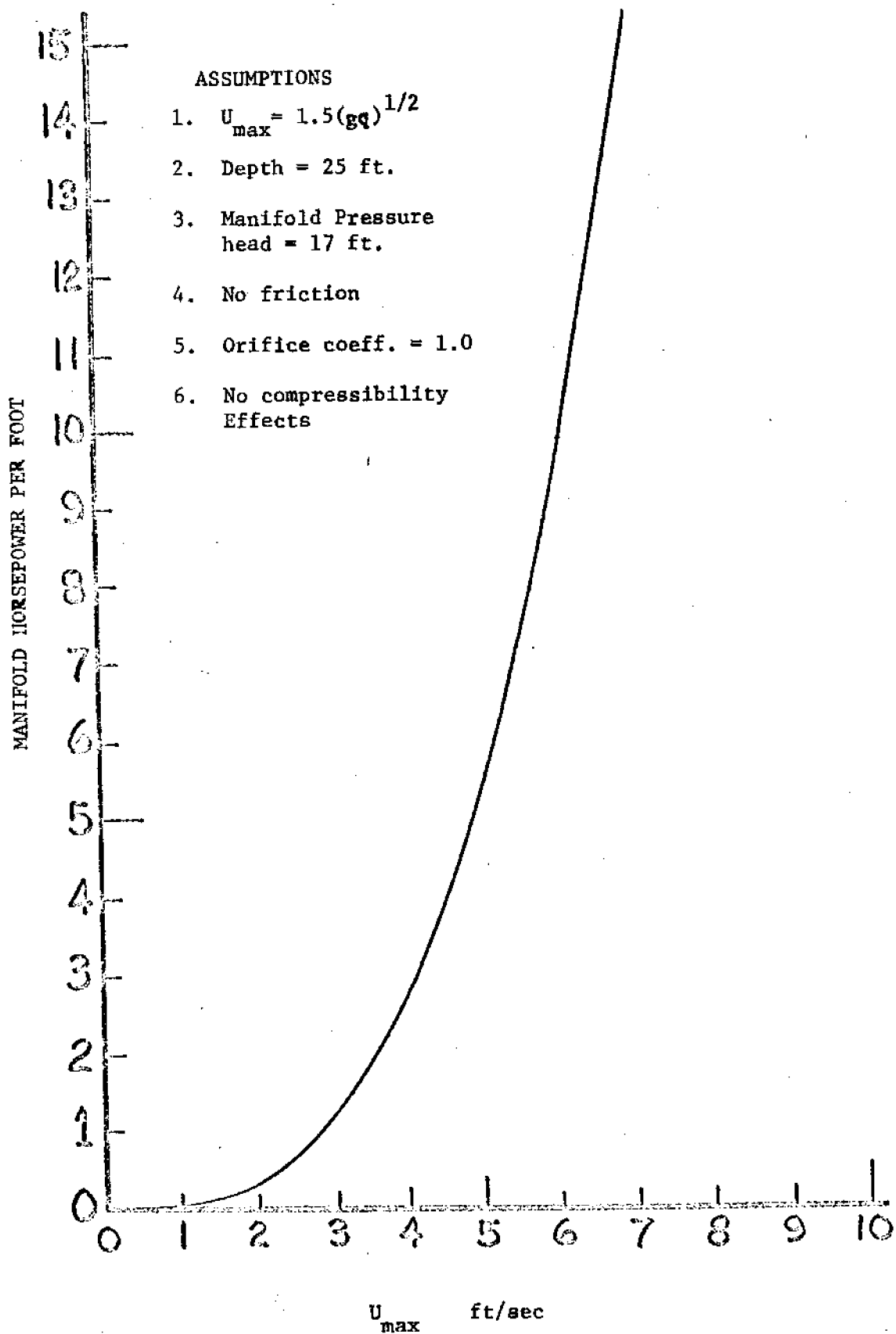


Fig. 8 - Horsepower requirements as a function of maximum surface velocity

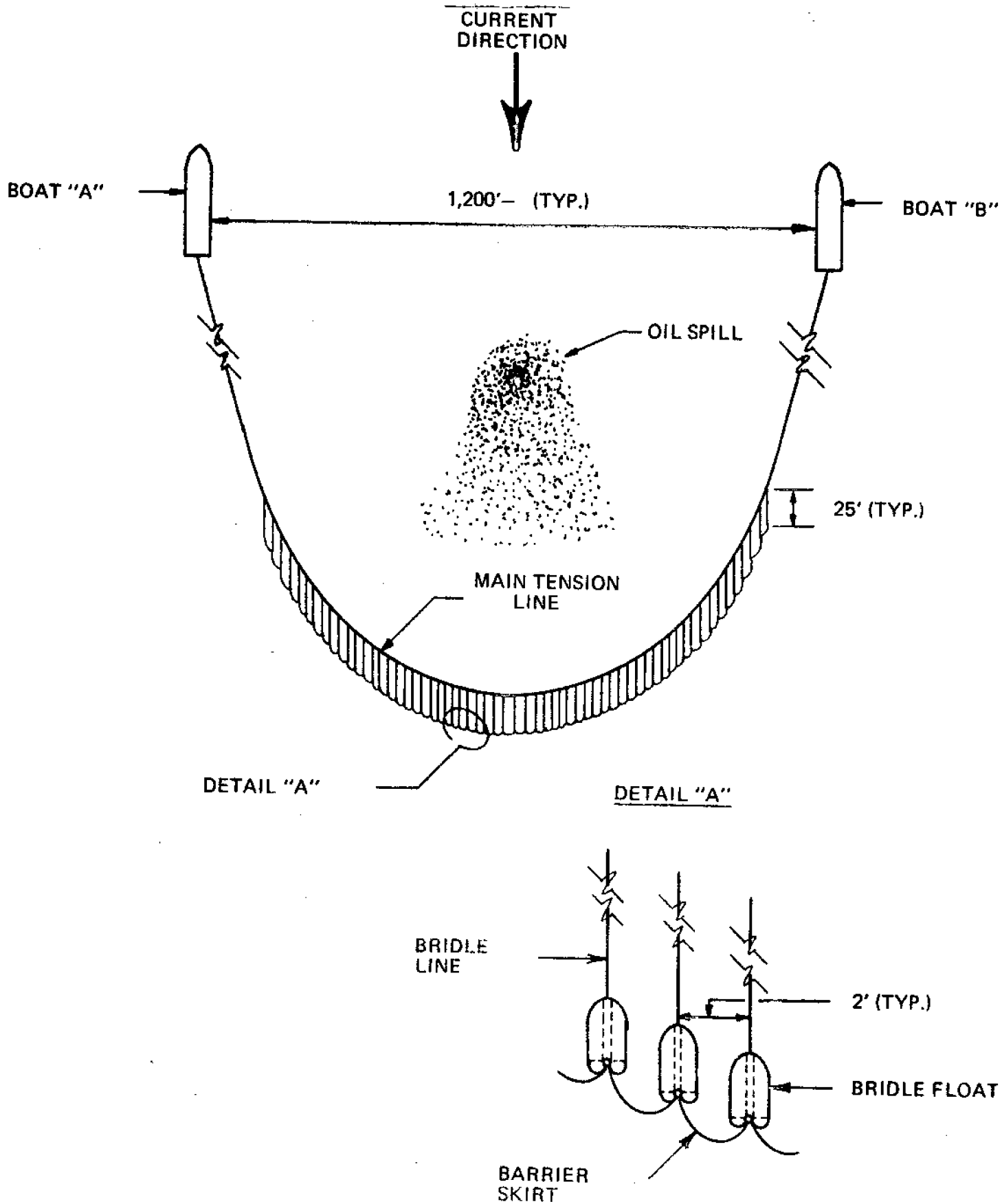


Fig. 9 - Texas A&M low tension barrier (from Reference 5)

tension is approximately 11 pounds. This should be compared to the thousands of pounds of tension in a "Navy Boom" type barrier.

2. Attaching the oil retention skirt to the rigid cable with long elastic shock cords, thereby allowing the flexible oil retention skirts to move with high waves, instead of being pulled under by the tension on the cable.

This configuration results in a barrier which will move freely with the surface of the water, absorbing little energy from waves. Consequently, this barrier is not subjected to the wave forces which have caused previous barriers to fail.

The barrier was designed to be parachuted and rapidly moved into position by any two standardly equipped vessels. The barrier is composed of an oil retention skirt having three feet below the surface and one foot of free-board to prevent waves from splashing over the barrier. The oil retention skirt is separated from the tension cable by 25 foot long elastic cords as shown in Figure 9.

This system can be towed for use as a pick-up device for removing oil from the surface of the ocean. However, it is not recommended to contain large volumes of oil, but rather to be used as the principal element in an active system for removing oil from the ocean surface. The active system is desirable as it prevents loss of oil past the barrier by the entrainment phenomenon.

The system is designed to be deployed and moved about by two vessels. This creates an artificial current to drive the oil against the barrier until it reaches a sufficient thickness to be pumped into storage tanks. The barrier should act as an excellent oil/water separator since its wave response ability provides a natural pump inlet for development of a pumping system.

The essential features of the Texas A&M Low Tension Barrier are detailed in Fig. 10. They are, with reference to the numbers in Fig. 10:

1. Main Float - sized to react the downward vertical component of the force in the elastic bridle lines.
2. Main Stiffener - 48 inches high.
3. Horizontal Stiffeners - prevent sag in freeboard.
4. Intermediate vertical stiffeners.
5. Weights housed in main stiffener to counteract upward forces when main tension cable is at a higher level than the skirt.
6. Weight in bottom of intermediate stiffener to provide stability.
7. Elastic Bridle Lines - allow the skirt to move horizontally in response to waves.
8. Main Tension Line - braided nylon. Polypropylene end sections equipped with load limiting fuses.
9. Stabilizer Lines.
10. Attachments Detail.
11. Horizontal Reinforcing Tapes.

The barrier system is packaged in a sealed container that maintains an inert gas atmosphere to prevent deterioration of the rubber shock cords and the other polymeric materials. Impact attenuation system on the bottom will deploy automatically when the container is air-dropped, thus reducing impact loads. Towing vessels can maneuver the barrier into the best position to intercept a moving oil spill. A multiple barrier arrangement can be deployed to control any size oil spill.

A 40-foot test section of the barrier was deployed in the Gulf of Mexico and towed at speeds up to five knots, with virtually no structural problems.

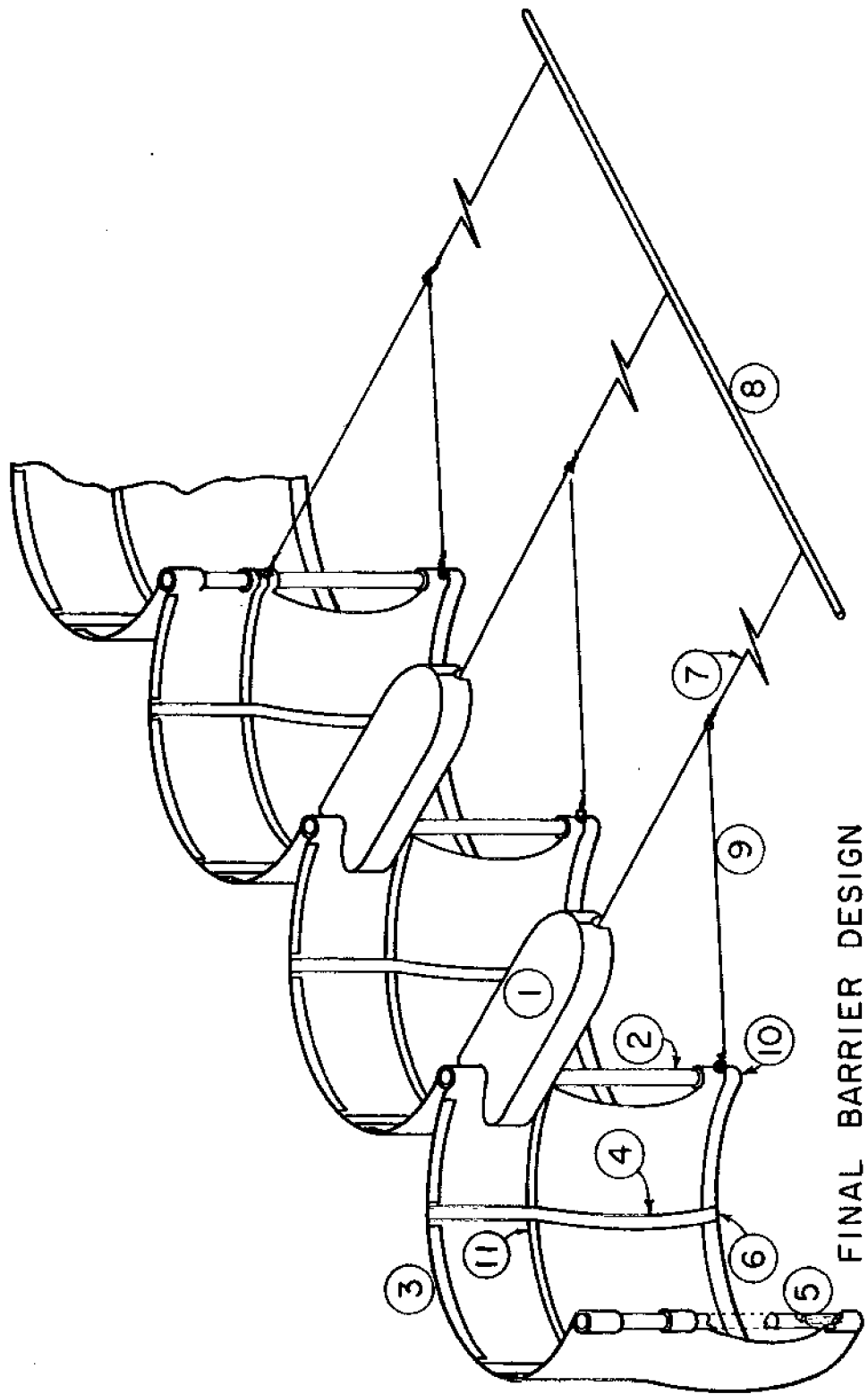


Fig. 10 - Low tension oil containment barrier detail (from Reference 5)

It was reported⁵ that as a containment device the low tension barrier should be totally effective in currents up to about one knot or in current-wave combinations which give a maximum one knot velocity of the barrier with respect to the sea. Above this velocity, oil entrainment and loss of oil under the barrier becomes a dominant failure mechanism.

The Texas A&M Low Tension Barrier will perform more efficiently than previous articulated barriers built with large amounts of flotation and fully articulated connections. Large tension forces effectively rigidized the booms to the extent that they could not respond to wave action. Identification of barrier dynamics and design of a barrier to accurately follow the ocean surface profiles the best concept for oil pollution containment.

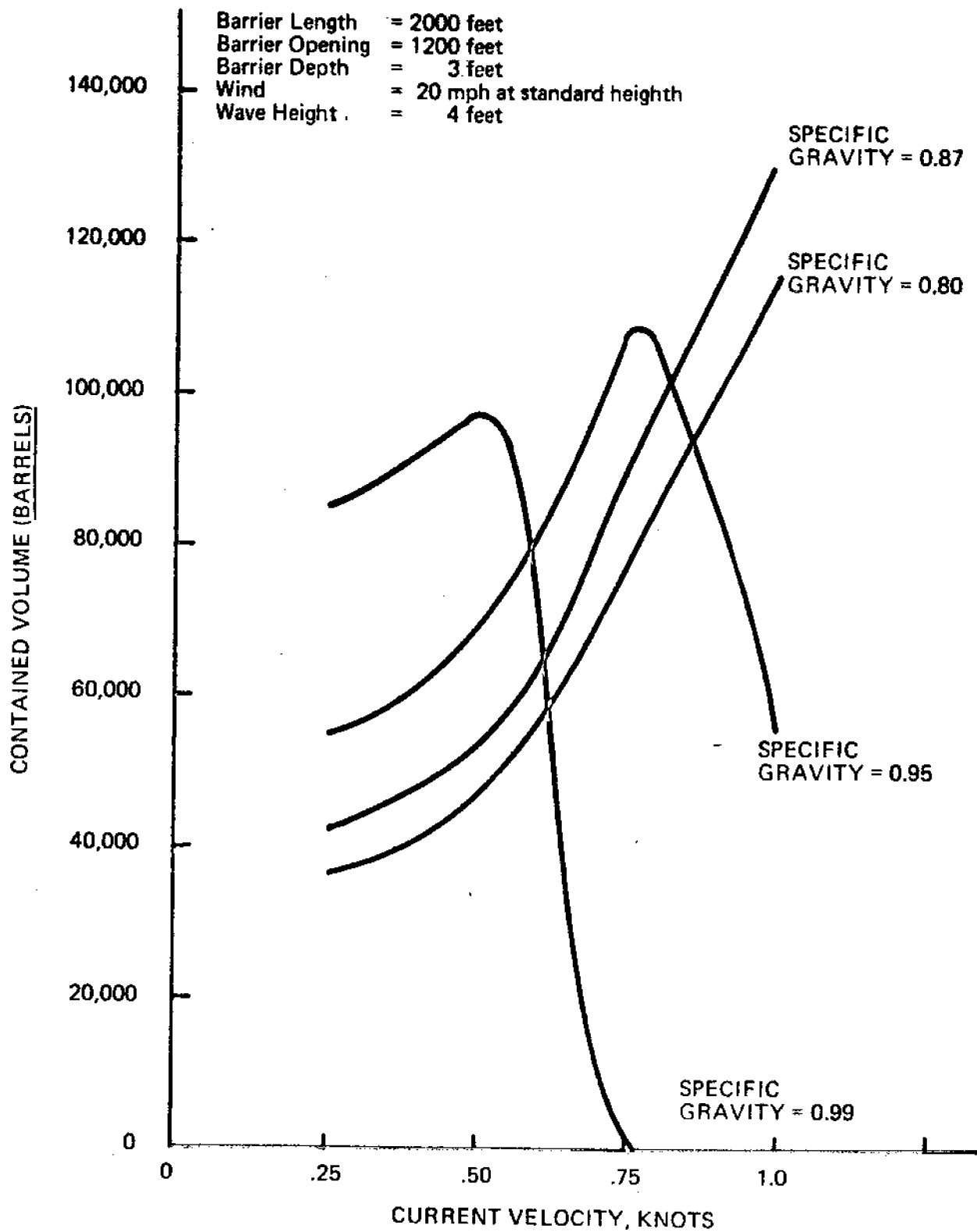
Oil Containment

The Texas A&M Low Tension Barrier has a capacity of over 100,000 barrels of oil under ideal conditions. Optimum size for containment, the barrier is long enough to cover the large areas in a typical oil slick, and deep enough to contain everything up to the onset of entrainment, where losses will begin to be so great as to make any depth barrier ineffective.

Figure 11 shows the containment capacity of the Low Tension Barrier. For low current cases, the Low Tension Barrier can for several days contain the expected pollution from offshore well accidents and from many tanker spills. A typical spill rate from an offshore well is 1000 barrels per day. With a one knot current and 0.87 specific gravity oil, the Low Tension Barrier could contain several months pollution, or over 100,000 barrels, if there were no environmental changes.

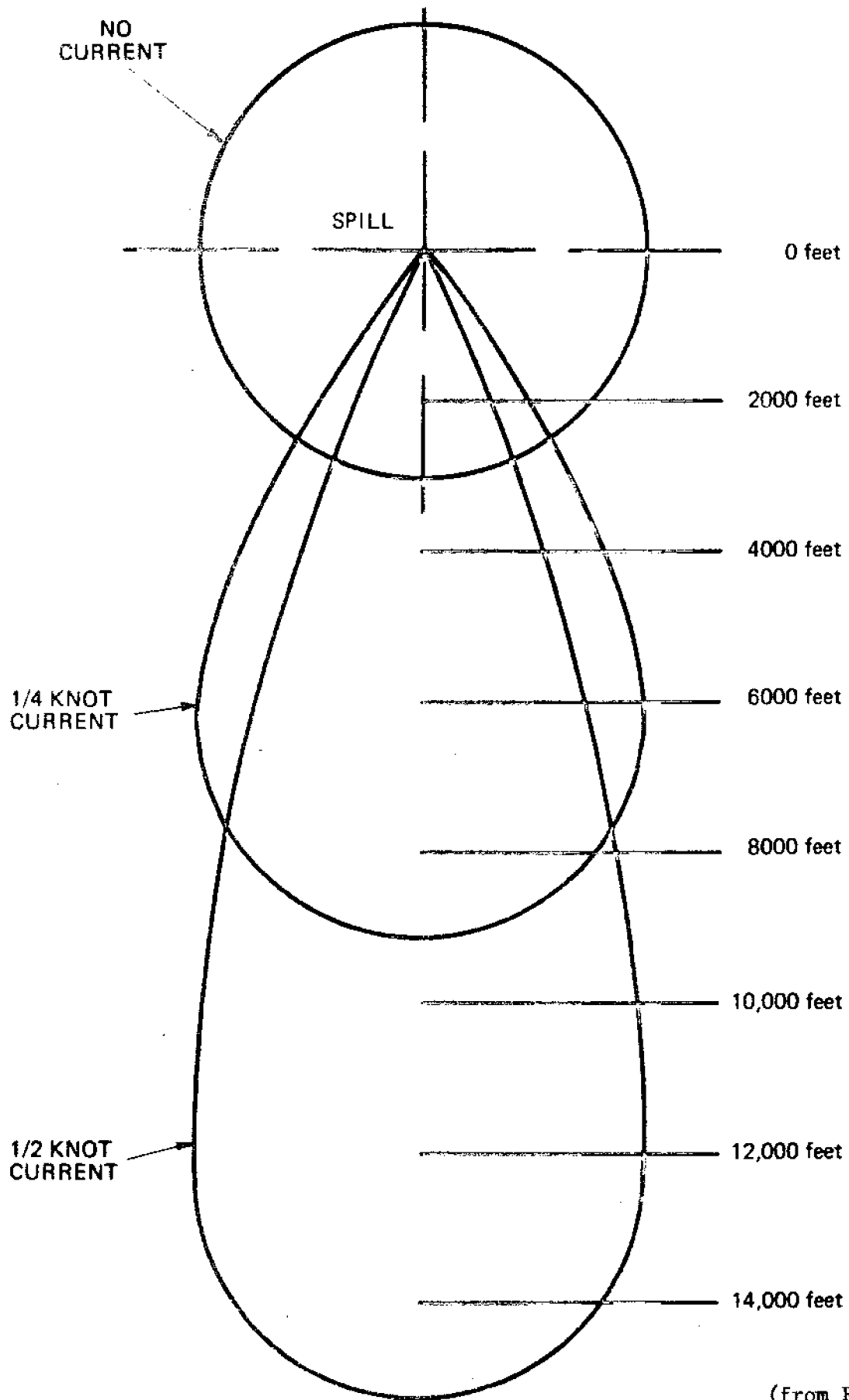
Deployment Losses

Figure 12 shows the expected four-hour shape of a 50,000 barrels/day spill, typical of a tanker-type accident.



(from Reference 5)

Fig. 11 -- Containment capacity of low tension barrier
under current, waves and wind conditions



(from Reference 5)

Fig. 12 - Expected shape of 50,000 barrel/day spill after 4 hours

A single package barrier having a 1200 foot opening should be sufficient for moderate currents (1/2 knot). It is necessary however to tow the barrier and to skim the large area covered by the spill. Volume is not a problem if the current and waves are small enough to rule out entrainment. If entrainment does occur, very small pumping rates are needed. A tanker-type spill, shown in Fig. 12, requires considerably more equipment. A barrier close to the spill would be the first deployed, assuming that the 50,000 barrels/day rate was continuing. With a four hour deployment, 6000-8000 barrels would remain to be cleaned up. At least one more 2000 foot length of barrier (1200 foot opening) would be required, along with pumping equipment, to clean up the spill.

REMOVAL OF OIL FROM WATER SURFACE

State-of-the-Art

Most mechanical skimming devices available or in a developmental stage have been used or demonstrated in waves less than 2-3 feet in moderate currents. These units remove the top layer of oil and water from the surface by overflow weirs, suction pumps or scoops and then separate the oil by gravitational action.⁷

Efficiency of the skimmers is limited by thickness of the oil spill. Most devices pump large quantities of water and small quantities of oil.

It appears important to concentrate the oil by using towed booms or skirts to sweep a large area. The system must also be flexible enough to respond readily to wave motion.

Sea Sweep

A patented oil skimming system called "Sea Sweep", developed by Ocean Pollution Control, Incorporated, is an adaptation of the principles used for many years in trawl fishing. The "Sea Sweep" is a tapered, flattened funnel assembly of wide-spaced net material, having a cover or top surface of flexible sheet material impermeable by oil.

Leading edge of the cover portion of the funnel assembly is held above the water surface by a series of floats. This assures that most of the oil will pass beneath it to be channeled into the collecting funnel, while the rear portion of the top cover rides upon the floating oil film. Sides of the funnel are also impermeable to prevent escape of oil as the funnel undulates in full conformance with sea surface.

Lower edges of the side panels are attached to a bottom panel of wide mesh netting which holds the skirts in a downward position to confine the oil, but permits water beneath the oil to pass freely through the bottom panel. The tapered shape of the collecting unit forces the oil toward the back to a collecting sump at the apex of the funnel. Oil and some water are collected and partially separated in the fore section of the sump.

From the sump the oil and some water are pumped through a floating hose to a barge for final separation, storage and oil removal. Figure 13 shows a plan view of the trawl-sump combination.

The sump separates and collects floating oil accumulated by the trawl for subsequent pumping through a flexible hose to storage gravity-separation tanks on a barge or a work boat.

The sump is partitioned into sections which accomplish partial separation and permit the oil to be pumped off with a minimum amount of water.

The system is delivered to the spill area via the afterdeck of its towing vessel. Once on site, the system is deployed using conventional winches, booms and deck crane, and under normal conditions, can be operative within 20 minutes.

According to a 1971 report, "Sea Sweep" operating in the vicinity of Shell Platform "B" fire off the Louisiana Coast did recover oil at a reasonable rate in six to eight foot seas.

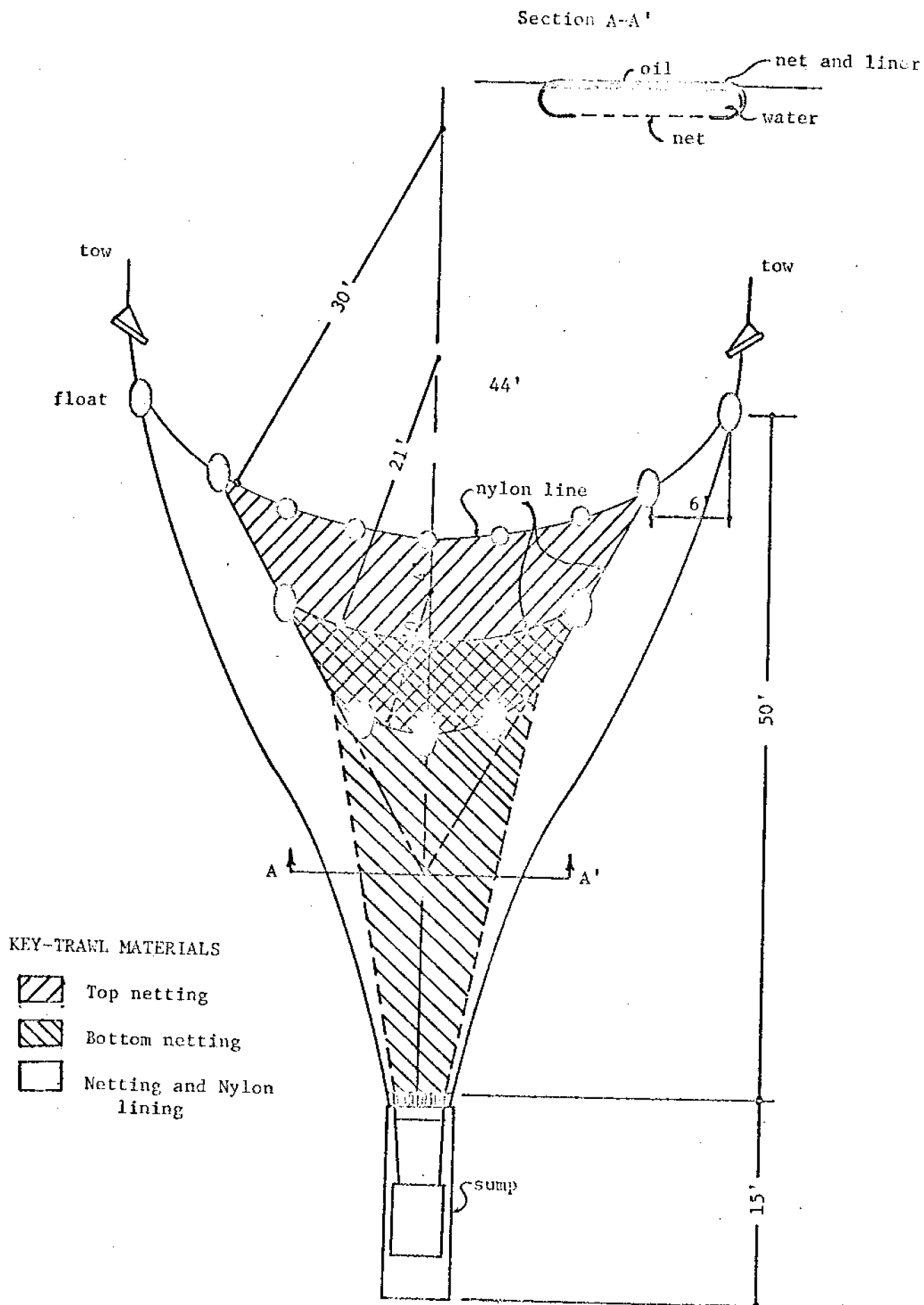


Figure 13 - Sump and Trawl, Plan View (Courtesy of Ocean Pollution Control, Inc.)

Vortex Principle

French Engineers¹ developed a purely mechanical method for removing oil from a contained area at sea. This method depends on creation of a localized forced vortex on the sea surface. The floating oil is forced to move toward the center of the vortex where it is pumped to a storage tank. Efficiency of the system for oil recovery under wave action would appear to be low.

Absorption of Oil

Soaking oil from the water surface by absorption is being investigated by several companies. Efficiency of these methods under current and wave conditions is unknown.

CHEMICAL TREATMENT

Methods of chemical treatment of oil spills are described in a Federal Government Report⁸. Methods which could be employed include

- a) dispersants,
- b) floating absorbents,
- c) sinking agents,
- d) gelling agents, and
- e) burning agents.

Dispersants

Dispersants serve to increase the surface area of an oil spill and disperse oil globules throughout the larger volume of water. This causes an accelerated degradation of oil by microbiological action. Desirability of employing dispersants in the open sea is subject to ecological considerations although their use is potentially more promising pending additional field testing and evaluation. After widespread dispersant use, reports concluded that more damage was caused to aquatic life by the dispersants than by oil alone. The problem is compounded on beaches by adding to the amount of pollutants present. The oil penetrates more deeply into

the sand, disturbing the sand's compactness, and increasing beach erosion through tidal and wave action.

Floating Absorbents

The absorbents include a wide range of materials with oil-attracting and water-repelling characteristics. Absorbents have unique advantages over other methods of oil cleanup, such as limiting the rate of slick spreading or facilitating cleanup, but they also possess a number of disadvantages, including delivery and application of the material, and collection and disposal of the oil-absorbent mass. Straw is used extensively as an absorbent because of availability, cheapness and effectiveness. A large investment in equipment and manual labor is required for removal of oil soaked straw. Natural products or those modified by heat and chemical treatment are also used as absorbents. Absorbent products with potential promise are those derived from the synthetic or plastic manufacturing field; of these, polyurethane and polypropylene are in greatest use. Collection and disposal of the oily mass poses greater problems than disposal of oil-water emulsions because of the relatively large bulk and the lack of efficient disposal techniques.

Sinking Agents

These agents adhere to the oil, absorbing and sinking the oily mass. For optimum effectiveness, little or no tendency for release of the oils back to the water environment should exist. Care should be exercised to prevent formation of a layer of "blanket" on the bottom, causing adverse effects on fixed shellfish beds and bottom feeding organisms. Sinking agents are most useful in deeper ocean waters outside heavy fishing zones for minimum adverse effects to productive biological life.

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D. Van Gonten, J.E. Martinez, E.L. Marquis, L.L. Lowery, L.D. Webb, R.M. Soren-
sen, C.J. Garrison, L.A. Hale, T.J. Kozik, T.A. Noyes, W.D. Langley and
T.I. Ichiye participated in the Light-Weight Oil Containment System (Ref. 5).

Cmdr. R. Abrahams and Lt. D. Teeson were the technical representatives
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Manuscript was prepared for publication by Miss Lucinda Kerley.

Gelling Agents

These agents, applied over the periphery of an oil slick or over the oil surface, provide another approach to oil spill containment and clean-up. The gelled mass still requires removal from the water surface.

Use of gelling agents over the periphery of an oil spill shows promise as a method for oil containment. Efficiency under wave conditions is however largely unknown.

Burning Agents

These agents offer a possible method of disposing of large amounts of oil over the water surface at sea, however the resulting air pollution may be objectionable. A few European Companies (one under contract with the Dutch government) can burn about 97 percent of the surface oil with present methods.

These agents offer a possible method of disposing of large amounts of oil over the water surface at sea where air pollution may be permissible. Past attempts have not been successful but potential value of this method warrants further research.

SUMMARY

The oil pollution problem in estuaries, along the shore and offshore is a serious one, but accelerated research is being conducted by the federal government, industry and universities. The research will no doubt bear fruit and eventually permit oil spill containment and disposal under current, wave and wind action in estuaries and at sea.

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